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Abstract

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J. R. Butler

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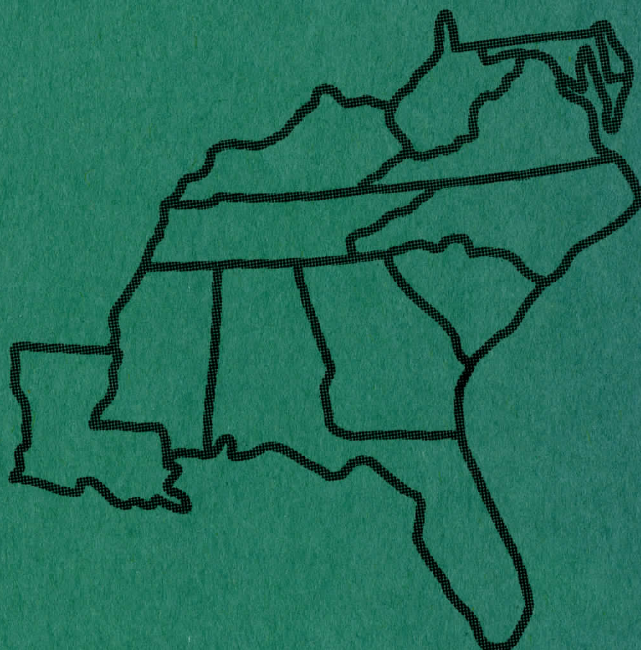

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SOUTHEASTERN GEOLOGY

Table of Contents

Vol. 7, No. 1

1965

THE GENERAL ABSENCE OF BLUE QUARTZ IN SEDIMENTARY ROCKS OF THE "FOLDED APPALACHIANS" OF SOUTHWESTERN VIRGINIA

by

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ABSTRACT

Blue quartz, typically as lens-shaped masses from about 10 to 30 mm in greatest dimension, constitutes up to 25 per cent of relatively widespread units of the Blue Ridge "Complex" of southwestern Virginia. These masses of blue quartz are presently so highly strained and/or fractured that they can be reduced, upon even relatively slight impact, to extremely fine grains that appear colorless.

There is unambiguous evidence that the Precambrian "Complex" rocks served as source material for at least some of the clastic material of the sedimentary rocks of the adjacent "Folded Appalachians" of the Valley and Ridge Province. The general lack of such blue-appearing quartz within these clastic rocks may indicate that this type of blue quartz of the "Complex" has been extremely susceptible to disintegration since inception of sedimentation in Late Precambrian or Early Paleozoic time.

INTRODUCTION

Blue quartz constitutes up to 25 per cent of relatively widespread units, such as the Little River Augen Gneiss (Dietrich, 1959), of the Blue Ridge "Complex" of southwestern Virginia. Typically this quartz occurs as lens-shaped masses ("eyes") from about 10 to 30 mm in greatest dimension.

Especially since quartz is known to persist through most weathering processes, a number of geologists have long wondered why almost none of this relatively abundant quartz has been recognized to occur within clastic rocks of the adjacent "Folded Appalachians" of the Valley and Ridge Province.

This note consists chiefly of an evaluation of considerations and data, both old and new, that bear on this apparent anomaly. Two questions appeared at the outset to be especially pertinent:

1. Were the blue quartz-bearing rocks of the Blue Ridge "Complex" exposed so they could have served as a possible source material for any of the clastic materials deposited within the sedimentary sequence that now comprises the "Folded Appalachians"?

and (if so)

2. Does this blue quartz have any property or combination of properties that causes it easily to lose or have changed its color during weathering, transportation, diagenesis, lithification, or post-lithification alteration?

Acknowledgments

W. E. Foreman of the Department of Mining Engineering of VPI made his laboratory available for the grinding tests; W. D. Lowry of the Department of Geological Sciences of VPI and S. D. Heron, Jr. of the Department of Geology of Duke University read and criticized the original manuscript. The writer gratefully acknowledges these contributions to this study.

THE BLUE RIDGE "COMPLEX" AS A POSSIBLE SOURCE

Several features indicate the Blue Ridge "Complex" to have been not only a possible source for clastic material by the time sedimentation was initiated in the area which now comprises the Valley and Ridge Province, but a probable source for at least some of the constituent sediments. Three features that appear to have special significance so far as the problem at hand are: (a) locally, rocks of the "Complex" are overlain nonconformably by rocks -- most of which appear to represent a strandline or near-shore environment -- of the oldest (Unicoi) Group of the sedimentary sequence of the Valley and Ridge and in some places even by pre-Unicoi, chiefly volcanic rocks; (b) rocks of the "Complex" occur as phenoclasts sporadically within these alluded-to volcanics, the Unicoi, and a few younger rocks of the sedimentary sequence that constitutes the bedrock of the Valley and Ridge; and (c) a small quantity of blue quartz has been found to occur as coarse sand- and granule-sized fragments at one locality within Unicoi Group rocks of the Valley and Ridge sequence of southwestern Virginia.

This does not mean, however, that the "complex" was a continuously possible source during the Paleozoic -- in fact, both geological and geochronological data appear to support the possibility that at least part of the area of the Blue Ridge "complex" was an intermittent site of sedimentation during pre-Silurian and possibly up to early Mississippian time.

Table 1. Results of Grindability Tests on Four Kinds of Quartz; Starting materials were angular fragments of: 1. White vein quartz, 2. Blue quartz from augen gneiss, 3. Partly weathered #2 and 4. Blue quartz from Roseland, Va.

Starting Material	Time, Min.	Size, → >4 mm. grns.	>4 gm.	2 - 4 grns.	2 - 4 gm.	1/2 - 2 gm.	1/16 - 1/2 gm.	<1/16 gm.	Total >1/2 gm.
1. WHITE vein qtz. 5 gms, 13 grns	2	10	2.9	9	.5	.1	.6	.9	3.5
	4	9	2.6	8	.6	.1	.3	1.4	3.3
	8	9	2.3	10	.6	.1	.5	1.5	3.0
	16	9	2.0	10	.5	.1	.6	1.8	2.6
	32	7	1.6	12	.8	.1	.6	1.9	2.5
	64	6	1.4	7	.9	.1	.6	2.0	2.4
2. BLUE Floyd Co. qtz. 5 gms, 13 grns	2	10	3.1	11	.4	.1	.3	1.1	3.6
	4	10	2.7	11	.3	.1	.3	1.6	3.1
	8	9	2.0	17	.6	.1	.3	2.0	2.7
	16	6	1.2	15	.6	.1	.2	2.9	1.9
	32	3	.3	20	1.0	.1	.2	3.4	1.4
	64	2	.2	23	1.1	.0	.2	3.5	1.3
3. WX. BLUE weathered #2 5 gms, 13 grns	2	9	1.8	25	1.3	.5	.7	.7	3.6
	4	7	1.3	33	1.4	.4	.4	1.5	3.1
	8	5	.9	32	1.3	.2	.3	2.3	2.4
	16	5	.8	28	1.0	.2	.3	2.7	2.0
	32	0	0.	28	1.3	.4	.3	3.0	1.7
	64	0	0.	25	1.1	.3	.3	3.3	1.4
4. Ro - BLUE Roseland, Va. qtz. 5 gms, 13 grns	2	8	2.7	14	.8	.1	.8	.6	3.6
	4	7	2.4	13	.8	.1	.6	1.1	3.3
	8	7	2.1	11	.6	.1	.7	1.5	2.8
	16	5	1.5	11	.7	.2	1.0	1.6	2.4
	32	3	.7	17	1.0	.3	1.2	1.8	2.0
	64	3	.5	12	.7	.4	1.2	2.2	1.6

CERTAIN PROPERTIES OF THE BLUE QUARTZ

The blue color (5 PB - 5/4) is, of course, the most readily apparent, distinctive feature of the quartz under consideration. Also distinctive, however, is a highly fractured (but still coherent) and/or strained quality. Megascopically, both of these features are evident; microscopically, the blue appears to have given way to colorlessness but the fracturing and/or straining are even more conspicuous. The strain is such that some portion of each "eye" is at extinction at each possible position of rotation of the stage between "crossed nicols." Further, most of the grains exhibit optical discontinuities that make them appear to be very near the point of being fragmented into nearly innumerable, extremely fine pieces.

When the blue quartz "eyes" weather out of the gneiss, some retain essentially their original coloration and shapes while others disintegrate into several, light gray to buff fragments. This chiefly mechanical breakdown appears to have been hastened by the micro-fracturing, even though most of that fracturing appears to be only incipient. The light gray fragments derived by such weathering probably would not be identified as having been blue if they were subsequently found in a sediment. Therefore, the answer to the first part of the second question posed in the Introduction (i.e. does this blue quartz have any property or combination of properties that cause it easily to lose or have changed its color during weathering...(?) seems to be: yes -- some of the quartz does lose its blue color during weathering probably enhanced by the highly fractured condition of that quartz.

The ultimate, near absence, of blue quartz grains requires further explanation, however, in order to account for grains that are still blue when they enter the transportation part of the erosion cycle. A possible solution to this aspect first became evident to the writer when he was grinding some of this, along with other, blue quartz for digestion in HF in order to free some of the reported (e.g., Watson and Beard, 1917) submicroscopic rutile needles for study. Even slight impact (using a mortar and pestle) resulted in reduction of the lens-shaped masses of blue quartz to chiefly fine sand- and silt-size, irregularly shaped, colorless fragments. Further, the extreme irregularity of these fragments seemed to insure even greater reduction upon even slight additional impact. This was in contrast to the fact that some of the other blue quartz (e.g. that from Roseland, Virginia) not only seemed to require greater impact for reduction but retained a bluish color even when reduced to silt- and clay-size material.

To elaborate on this, so far as the lens-shaped blue quartz of the gneisses: in general, fragments of greater than medium sand size may be distinguished from fragments of other quartz, e.g. vein quartz, of the terrain on the basis of color but fragments of smaller size are colorless to very light gray and can be only tentatively identified as "blue quartz" on the basis of their exhibiting the already referred-to, highly fractured and/or strained quality. Titanium-content does not, as previously suggested (e.g. Frondel, 1962, p. 190 and Tbl. 27), appear to constitute an absolute criterion -- this will be discussed in another paper (Dietrich et al., ms in preparation).

The suggested breakdown behavior was subsequently investigated by a series of tests in which small, pebble-size (4 - 8 mm) angular fragments of this type of blue quartz (both fresh and weathered), of Roseland blue quartz, and of white-to-milky vein quartz were subjected to dry grindability tests for different measured periods of time in a vibrating impact grinder.

The vessels in which the grinding was accomplished are about 41 mm in diameter, about 42 mm long, and are lined with tungsten carbide; the vibration equipment employed was a Spex Industries #8000-11 mixer-mill with an approximately 950 cycles per minute operating speed during the tests herein reported. The weights given on Tables 1, 2, and 3 are to the nearest 0.1 of a gram. The weight for the $<1/16$ mm fraction is by difference. There was some loss of this fine fraction during the sieving and weighing operations, but certainly less than that lost in nature by removal in suspension.

The complete results of these tests are tabulated in Tables 1, 2, and 3 and certain of them are plotted on Figures 1 and 2.

Nearly all of the >4 mm and a notable percentage of the >2 mm "blue" grains remaining after the first 16 minutes of grinding consist chiefly of rock (gneiss) material originally attached to the blue quartz "eyes". The >2 mm size fragments derived by grinding the partially weathered blue quartz have a greater angularity and lower sphericity than the fragments derived from the other tested materials (except for those from the runs in which blue quartz was ground along with the sand) and there also is a notably larger percentage of 1/2 - 2 mm size fragments derived from this material.

The 1/2 mm "cut-off" used for Figure 1 is merely for comparison and consistency with Figure 2. This cut-off was used for Figure 2 because it seems unlikely that $<1/2$ mm sand-, silt-, and clay-size fragments would be deposited with the coarser fractions -- if they were, the White:Blue ratio would be even greater than indicated on the figure because the $<1/2$ mm fragments do not appear blue. In general the 1/2 - 2 mm fraction also lacks a blue appearance and so was considered "White" in calculating the ratio. (The Roseland blue quartz, on the other hand, has a bluish appearance even in the 1/16 - 1/2 mm fraction.)

Although the tests do not simulate natural conditions, the results are considered to be indicative. They are interpreted to suggest that: the blue quartz from the gneiss of Floyd County is more easily fragmented than the other kinds of quartz tested (Table 1 and Figure 1); the differential is greater when this blue quartz is subjected to dry, impact grinding along with the apparently relatively less easily fragmented white vein quartz; the differential is even greater when the blue quartz is ground along with small pebble-size, rounded, vein quartz grains and sand grains; and, somewhat surprisingly, the differential is even greater when the blue quartz is ground along with only sand.

This seems to supply the answer to the remainder of question two, as posed in the Introduction: the blue quartz of the gneiss which is still blue when it enters the transportation part of the erosion cycle breaks relatively easily into small, colorless to light gray fragments so that typically most of it (or of its blue color, if the reader prefers) would be effectively lost, so far as being incorporated in any sediment, as a result of fragmentation during transportation. (Thus, the other aspects -- possible loss or change of color during diagenesis, lithification, or post-lithification alteration -- do not require consideration.) The present-day presence of blue quartz in residual materials and the general dearth of it in stream deposits derived in part from the gneiss and its overlying weathering products may be

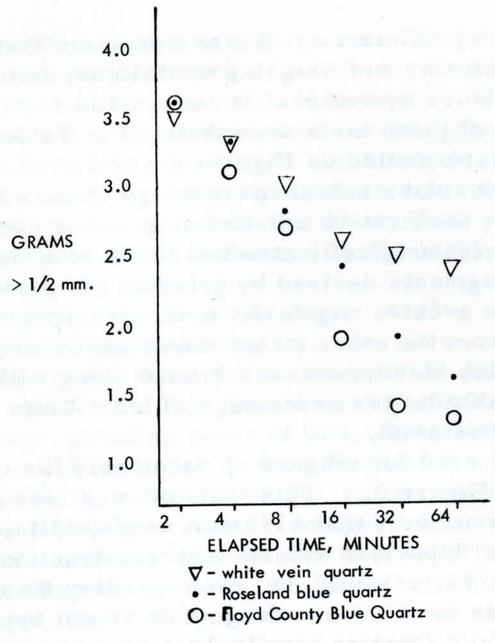

Figure 1. Amounts, by weight, of fragments greater than 0.5 mm in size remaining after grinding for different elapsed times (based on data given in Table 1). Starting charge for each run was 0.5 gm. Triangles represent white vein quartz (run 1); circles represent Floyd County blue quartz (run 2); dots represent Roseland blue quartz (run 4).

considered as permissively corroborative.

FURTHER CONSIDERATIONS

Although the blue quartz in the gneiss is now of such character that it breaks rather easily, this does not necessarily mean that it did when sedimentation was initiated in the present Valley and Ridge region. In fact, some relationships, such as the presence of this blue quartz-bearing gneiss within a fault zone also involving formations as young as the Middle Cambrian Rome Formation might, be interpreted to suggest, alternatively, that the quartz gained its fractured character during the Post-Rome faulting and thus at least as late as the time after which the Rome Formation was lithified.

The writer believes, however, that all known data support best the hypothesis that the blue quartz did have essentially its present fractured character before initiation of Unicoi sedimentation and that this accounts for its general absence in clastic rocks of the Valley

Table 2. Results of Grindability Tests on Mixtures of Floyd County Blue Quartz and White Vein Quartz; Starting materials: 5 and 6, Angular fragments of both kinds of quartz; 7. Angular fragments of blue quartz with rounded fragments of white quartz.

	Size, mm. → / Time, Min. ↓	>4 B grns.	>4 B gm.	>4 W grns.	>4 W gm.	2 - 4 B grns.	2 - 4 B gm.	2 - 4 W grns.	2 - 4 W gm.	1/2-2 gm.	1/16-1/2 gm.	<1/16 gm.	Total >1/2 gm.
5. Wht. + Bl. 2.5 grms, 7 grns, of each	2	6	1.6	7	2.0	7	.3	1	.1	.1	.3	.6	4.1
	4	4	1.1	7	1.7	10	.5	1	.1	.1	.2	1.3	3.5
	8	3	.7	6	1.4	9	.4	1	.1	.1	.3	2.0	2.7
	16	3	.5	6	1.3	9	.4	1	.1-	.1	.2	2.4	2.4
	32	2	.4	6	1.3	11	.4	1	.1-	.1	.1	2.6	2.3
	64	2	.3	6	1.2	8	.3	1	.1-	.1	.1	2.9	2.0
6. Wht. + Bl. 2.5 grms, 7 grns of each	2	5	1.0	7	1.7	10	.8	1	.1-	.2	.2	1.0	3.8
	4	4	.8	7	1.5	12	.8	0	0.	.1-	.2	1.6	3.2
	8	4	.7	7	1.4	12	.7	0	0.	.1-	.2	1.9	2.9
	16	2	.4	7	1.3	11	.6	0	0.	.1	.2	2.4	2.4
	32	2	.4	6	1.1	9	.5	1	.1+	.1	.2	2.6	2.2
	64	0	0.0	6	1.1	13	.5	1	.1+	.1	.2	3.0	1.8
7. Wht. (rdd) + Bl 2.5 gms, 7 grns, of each	2	4	1.1	7	2.4	10	.6	0	0.	.1	.1	.7	4.2
	4	4	.8	7	2.3	10	.4	0	0.	.1	.1-	1.3	3.6
	8	3	.5	7	2.0	10	.3	0	0.	.1-	0.+	2.1	2.9
	16	1	.1	6	1.6	9	.4	1	.1	0.+	.1-	2.7	2.2
	32	0	0.0	6	1.6-	10	.3-	1	.1-	0.	.1-	2.9	2.0
	64	0	0.0	6	1.5-	5	.2	1	.1-	0.	.1-	3.1	1.8

Table 3. Results of Grindability Tests on Mixtures of Floyd County Quartz with Chiefly Quartz Sand plus and minus Rounded Fragments of White Vein Quartz; Starting materials: 8. Floyd County Blue quartz and medium quartz sand, and 9. Floyd County blue quartz, rounded fragments of white vein quartz, and medium quartz sand.

	Size, mm. → / Time, Min. ↓	>4 B grns.	>4 B gm.	>4 W grns.	>4 W gm.	2 - 4 B grns.	2 - 4 B gm.	2 - 4 W grns.	2 - 4 W gm.	1/2-2 gm.	<1/2 gm.	Total >1/2 gm.
8. Bl. (7 frags, 2.5 gm) + sd. (2.5 gm)	2	6	1.4			8	.4			1.1	2.1	2.9
	4	4	.8			13	.6			.5	3.1	1.9
	8	3	.5			20	.8			.2	3.5	1.5
	16	2	.4			20	.7			.2-	3.7	1.3
	32	2	.3+			19	.6			.1	4.0	1.0
	64	2	.3-			17	.5+			.1-	4.1	0.9
9. Bl. (4 frags, 1.25 gm); wht. (4 rdd. frags, 1.25 gm) + sd. (2.5 gm).	2	3	.5	4	1.2-	8	.5	0.	0.	1.4	1.4	3.6
	4	3	.4	4	1.1	8	.3+			.6	2.6	2.4
	8	2	.2	4	1.1-	8	.3			.2	3.2	1.8
	16	2	.2-	4	1.1-	7	.3			.0+	3.4	1.6
	32	2	.2-	4	1.0	5	.2			.0+	3.6	1.4
	64	0	0.	4	1.0-	7	.3			.0+	3.7	1.3

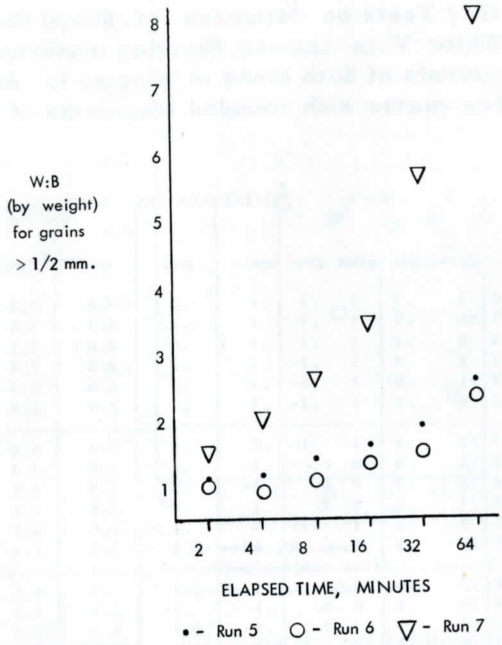

Figure 2. Ratios of White:Blue fragments (by weight) after different periods of grinding (from data on Table 2). Dots and circles represent runs numbered 5 and 6, respectively; triangles represent run number 7.

and Ridge sequence. This also may suggest that at the present level of erosion, the Fries Fault within the area represents post-Rome reactivation of a preexisting fracture (fault?) zone. Among pertinent supporting data are the presence of epidote veining along fractures within the gneiss and its absence along fractures within the sedimentary rocks of the footwall block and the aforementioned presence of phenoclasts (including highly fractured ones) of "Complex" rocks within the Unicoi Formation.

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NOTES ON TECHNIQUE FOR SAMPLING SUSPENDED SEDIMENT

by

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ABSTRACT

Equipment and procedures which have been used to sample relatively large quantities of suspended sediment from shallow ocean waters, bays, and streams are described. Water and sediment are pumped from an intake set at the desired depth and are processed by a continuous-flow centrifuge to obtain the sediment. The system may be operated from a small vessel on larger bodies of water or from a fixed position for sampling streams.

* * *

In connection with a study of the sedimentology of the Delaware Bay and adjacent shelf, samples of suspended, as well as bottom, sediments have been taken. A system of obtaining relatively large samples of adequate quality of suspended material has been devised, tested, and operated under a variety of conditions. An objective of the sampling was to obtain representative samples of sufficient size to permit mechanical and mineralogical analysis. Because of the low sediment concentrations prevailing under most natural conditions, large amounts of water-sediment mixture must be processed. An efficient means of accomplishing this is a valuable aid in a study of modern sedimentation.

Two main elements are involved in the sampling of suspended sediment: (1) obtaining the water and sediment, and (2) separating and retaining the sediment. The system which will be described utilizes a pumping sampler to obtain the sample and a continuous-flow centrifuge to effect the separation of solid and liquid phases. The components and their arrangements are shown in Figure 1.

Perhaps the most critical portion of any such system is the intake itself. The excellent studies of the Federal Inter-Agency Committee of Water Resources (especially 1941, 1952, and 1962) define

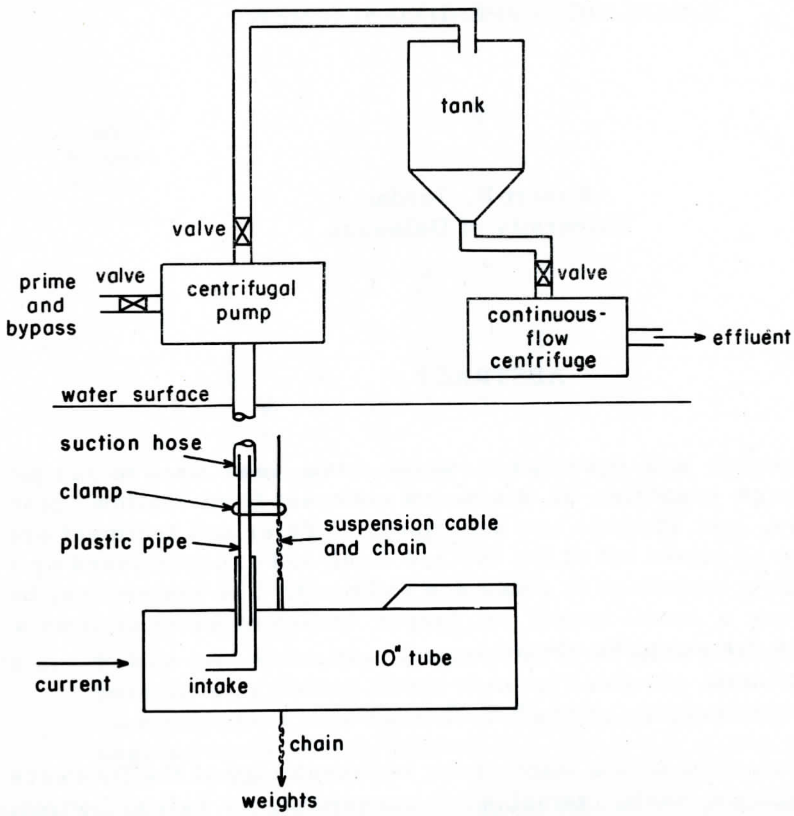

Figure 1. Schematic diagram of system for sampling suspended sediment.

design problems and discuss various devices and systems for the sampling of sediment-laden water. Standard sampling tools and techniques are used by various agencies. Fundamental requirements of a sampler include: maintenance of a stable attitude in the water; minimal disruption of flow; sensitive directional alignment with current with intake facing into current; and, approximate agreement of intake velocity with current velocity.

The body of the intake system constructed consists of a sheet metal tube 10 inches in diameter and 4 feet long. A frame is fitted so that the tube, with a fin at the rear and weighted for balance, can be suspended through a chain and swivel attached forward of the center of the tube. Lead weights are hung below the unit, also on a chain and swivel. The actual intake is a length of 1.5 inch diameter pipe centered in the tube and opening forward. An elbow connects this with a vertical pipe essentially coaxial with the suspension chain. It would seem that considerable scope in design is possible provided that the criteria indicated are satisfied. The present unit was tested in streams where it could be closely observed. It was found to be stable and have good directional sensitivity; however, it does have a high drag.

The underwater intake is lowered to a selected depth and connected to a pump by means of a flexible suction hose attached to a plastic pipe inserted in the vertical pipe of the sampler. The connecting pipes and hose may be varied for different depths and operating conditions. They are ordinarily clamped to the cable by which the unit is suspended in order to reduce bowing in currents. The pump used is a commercial one-half horsepower electric centrifugal. It, and all pipes and connections, were disassembled and cleaned, smoothed, and treated with rust resistant paint periodically. Under the operating conditions encountered the pump produced about 20 gallons per minute. As long as it was operated at or near this maximum, no sediment deposition was observed in the intake, pipes, or pump. Because the output of the pump far exceeds the capacity of the centrifuge used, its effluent was discharged into a 30 gallon tank fitted with a steep conical base and bottom discharge. The tank was mounted to provide gravity feed to the centrifuge.

Calculated velocities at the intake approximated the usual natural velocities encountered. Some extremes of high and low current velocities did result in discrepencies, generally with intake velocity exceeding natural velocities. The most serious sampling errors result when the sampling rate is considerably lower than water velocity, and errors are much greater with sands than with finer sediment (Inter-Agency Committee on Water Resources, 1941). Extremes of velocity contrasts (ratio of velocity of intake to natural flow velocity) encountered ranged from about 0.6 to 3.0, although the usual situation approximated unity. Preliminary results of mechanical analyses of the sediments collected indicate median diameters around fine silt, and poor sorting with the largest particles in fine sand. Consideration of these conditions and the curves in Report No. 5 of the Inter-Agency Committee on Water Resources (1941) suggests that distortion of the size distribution is negligible for the purposes of an initial study of sedimentology.

The centrifuge used is a DeLaval "Gyro-Tester" unit fitted for continuous flow operation and retention of solids. It was operated at flow rated of about three-fourths to one gallon per minute. The writer was first introduced to the use of such a unit for the sampling of solids in natural waters by Johan J. Groot of the University of Delaware. Groot's unit was used initially for the recovery of pollen from sea water and has, subsequently, recovered sediment in ocean waters (Groot and Ewing, 1963). In the present investigation the unit has been quite efficient in the removal of very fine particles. Mechanical analyses now in progress measure grain size down to about 2 microns (considerable finer material is present) and yield cumulative curves without indication of bias. Centrifuges of greater capacity are commercially available and their use would materially reduce the amount of time required to obtain a sample.

Sampling on the Delaware Bay and the Atlantic Ocean near the mouth of the Bay was done from the University of Delaware's 46 foot research vessel Wolverine. The sampling intake was lowered from the side of the anchored vessel to a selected depth and a current velocity and direction meter operated at the same depth from the other side. Salinity and temperature measurements were made at this depth simulteneous with the pumping of the sample. Bottom samples were taken with gravity corer and dredge. Operation conditions in open water included depths of from 15 to 160 feet and current velocities up to more than 2 knots. Provided all gear is reinforced for shipboard service and suitably anchored, the operation may be performed in moderately rough weather. From 30 to 100 gallons of water were processed for each sample and between 0.5 and 50 grams of sediment were retained.

For sampling streams, power may be supplied by a portable generator and the intake suspended from a low bridge or other fixture. Alternatively, the intake may be lowered from a small boat anchored in the stream and the other equipment placed on the bank. Such arrangements have been used to sample the Delaware, Schuylkill, and Brandywine Rivers and smaller streams in Delaware.

The equipment described is crude but has proven effective and versitile. It is also relatively inexpensive and portable. Many improvements may be suggested for specific applications. Whatever the final design and degree of sophistication however, the basic combination of pumping sampler and a continuous-flow centrifuge appears to be a satisfactory approach to the problem of obtaining large quantities of suspended sediment for petrologic study.

The support of the study of the Delaware Bay area by the University of Delaware Research Foundation is gratefully acknowledged.

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BOTTOM TOPOGRAPHY OF THE GEORGIA CONTINENTAL SHELF

by

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ABSTRACT

A topographic map of the Georgia continental shelf is presented. The shelf is 70 to 80 miles wide and breaks at depths between 50 and 80 meters. The major feature observed is an ill defined valley which was probably occupied by the Altamaha River during the Pleistocene.

INTRODUCTION

During the summer of 1963 and 1964, a series of bottom sampling cruises were made on the University of Georgia Marine Institute research vessel "Kit Jones". During the course of these cruises fathograms of the Georgia Continental Shelf were obtained. Figure 1 shows the bottom sounding traverses or lines of fathogram records. Since at the present time no accurate bottom topography maps of the outer Georgia shelf are available it was decided to publish this preliminary note.

The fathometer used is an Elac, Castor model with a maximum depth range of 2,200 feet. No corrections of any kind were applied to the depth figures. Bottom soundings recorded on U.S.C.G.S. chart No. 1111 of less than 15 meters depth were also utilized.

The support of the National Science Foundation in this study is gratefully acknowledged. The writers wish to thank Captain Jim Kouse for his cooperation and help at sea.

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1. University of Georgia Marine Institute Contribution Number 95.

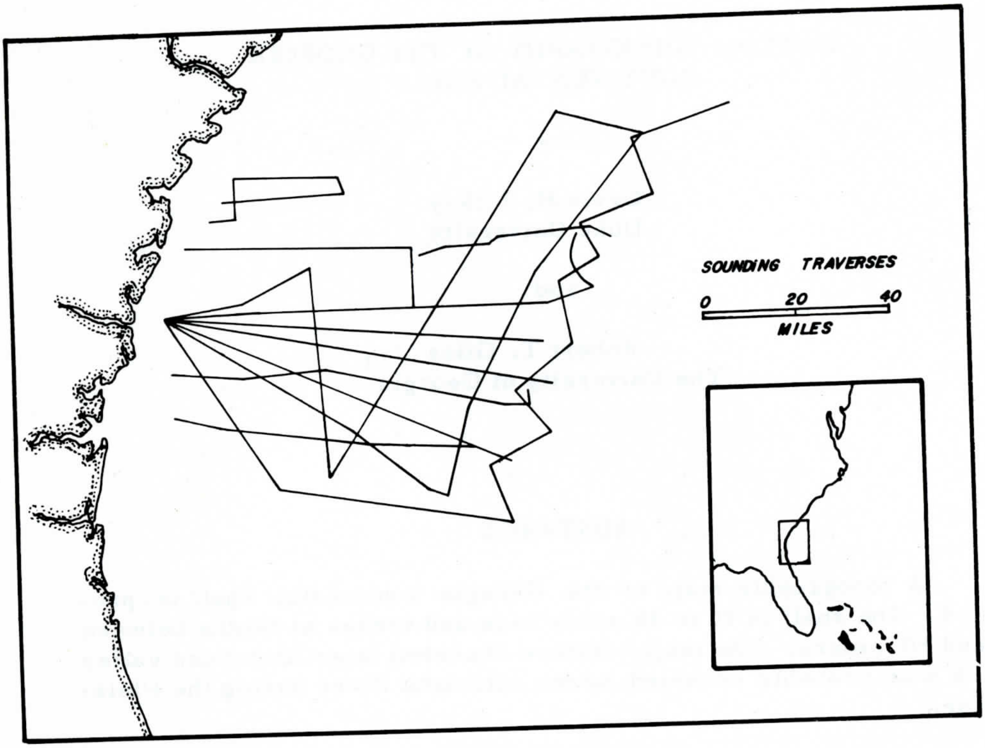

Figure 1. Map of the study area showing lines of bottom soundings upon which the topographic map is based.

DISCUSSION

Figure 2 is a topographic map of the Georgia shelf. Note the change of contour interval at the shelf edge.

The continental shelf of Georgia is a very gently dipping extension of the Atlantic Coastal Plain surface averaging only a fraction of a degree slope. Relief on the shelf is by and large quite subdued. Local relief of as much as 5 or 6 meters was observed but this is rare.

The continental shelf-continental slope break occurs at depths in the vicinity of 50 meters in the southern portion of the study area and 80 meters to the north. These depths are considerably less than the world wide average shelf break. The change from shelf to slope is sharp and sudden in the south but less so to the north in this area. The width of the continental shelf ranges from 70 to 80 miles.

The dominant features on the Georgia continental shelf are an ill defined low relief valley, east of Sapelo Island which is bordered to the south by a gentle ridge. It is likely that this feature is a filled valley formed by the Altamaha River during lowered sea levels of the Pleistocene. The Altamaha River empties into the Atlantic in the vicinity of Darien (Figure 2). A second, more poorly developed or preserved valley is present along the southern margin of the map area.

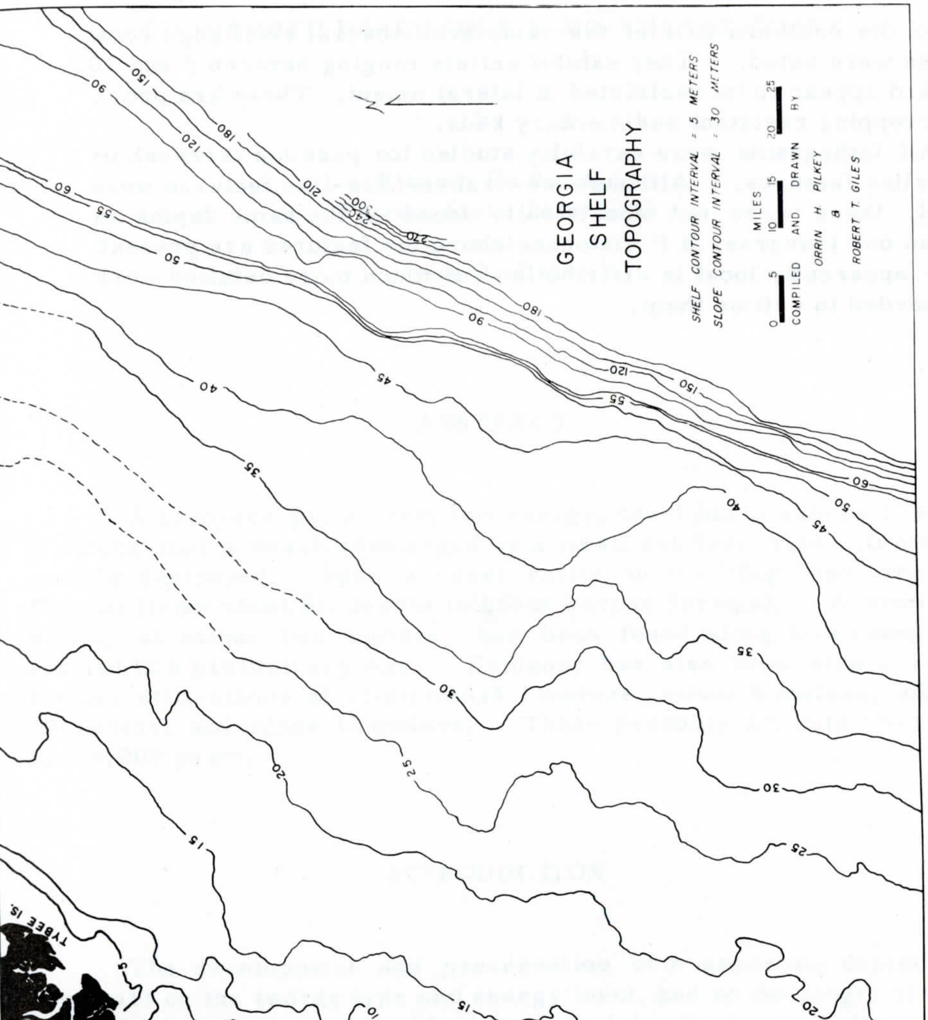

Figure 2. Topographic map of the Georgia continental shelf.

No topographic expressions of the valleys are present on the small upper portion of the continental slope examined during this investigation. In fact, except for a zone in the vicinity of the shelf break, the continental slope is quite smooth and featureless.

In the southern half of the study area several shelf edge rock (?) ledges were noted. They exhibit reliefs ranging between 5 and 10 meters and appear to be restricted in lateral extent. These are probably outcropping resistant sedimentary beds.

All fathograms were carefully studied for possible terraces or old shoreline features. Although several terrace-like features were observed, these were not consistently found at the same depths on more than one traverse. If Pleistocene shoreline features are present, they are apparently local in distribution and much more detailed work will be needed to outline them.

SUBMERGED BEACH ON A ZERO-ENERGY COAST

by

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and
John D. Bates [1]

ABSTRACT

A zero-energy, or very low energy, coast has breakers of such a nature that a beach submerged by a small sea level rise will not be readily destroyed. Such a coast exists in the "Big Bend" area of Florida (from about St. Marks to about Tarpon Springs). A drowned beach, at minus two meters, has been found along this coast and studied in a preliminary way. Evidence has also been obtained for former still-stands at about minus 7 meters, minus 8 meters, minus 10 meters, and minus 12 meters. These probably all date from the last 8,000 years.

INTRODUCTION

The development and preservation of a shoreline depends in good part on the energy type and energy level, and on the length of time over which that energy is applied in one relatively narrow belt. For wave-type features, such as a beach, assuming that suitable beach materials are available to the breakers, construction time is a direct function of energy level. That is, with a suitable supply, high energy waves build a beach much more quickly than low energy waves, and in a truly zero energy environment no beach will ever be built. The concepts compressed into this paragraph are absolutely fundamental to a understanding of coastal evolution. However, it is not the purpose of this note to examine these concepts, but rather to show how they lead to investigation of another problem.

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1. Deceased; formerly consulting geologist, Tallahassee, Fla.

In many area, suitable materials are not available, and therefore any beach which may be present (inherited from a previous regime), will be destroyed at a rate which is directly proportional to the energy level.

Consider an area in which a beach is built slowly (low wave energy). After the beach is fully developed, sea level rises a given amount. A new beach is now built, and at the same time the old beach is subjected to attack. The higher the wave energy, the more quickly both tasks will be accomplished.

SUBMERGED BEACHES

The problem which is investigated in the present note is: Under what energy conditions should we expect to find a beach, well-preserved, for an appreciable period after a 1-meter or 2-meter rise in sea level? If wave energy is truly zero, we expect no beach at all. If wave energy is high, we expect the old beach to be destroyed quickly. Therefore, we look in areas of very low to low wave energy levels, for shallow submerged beaches.

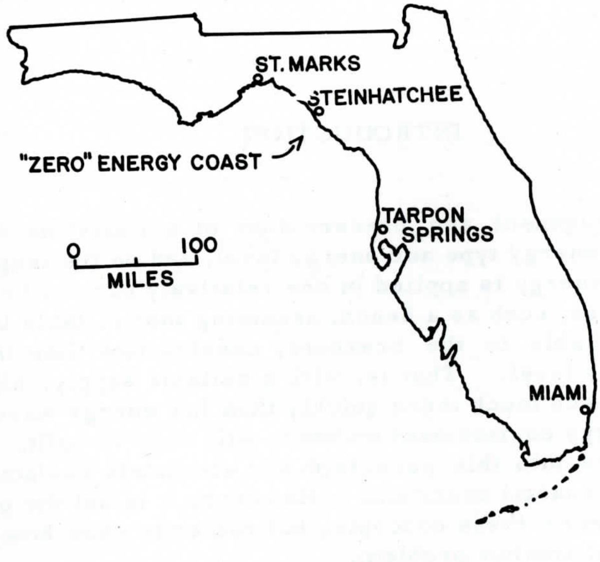

Figure 1. Map of Florida, showing the location of the "zero" energy coast.

Inasmuch as sea level has had a general rise, from about 20,000 to roughly 5,000 years ago, and furthermore, inasmuch as that rise must have come in fairly small increments, we look for shallow submerged beaches (late in the history of the rise), and we look in areas where wave energy is at or near a minimum.

From observation of modern coasts, the conclusion can be drawn that the minimum effective wave energy level necessary to build a beach is indicated by breakers having an average height not far from 3 or 4 centimeters. In order to study a fairly late, shallow, submerged beach, we should investigate a coast where present breaker heights are very close to zero. Such a stretch of coastline can be found in the Big Bend area of Florida, southeast of Tallahassee, from approximately St. Marks to Tarpon Springs (Figure 1). The purpose of the present note is to report the results of exploration of the minus-two-meter shoreline in the selected area.

The preliminary data reported here are the result of investigations along the Florida coast over a period of about six years.

The minus-two-meter shoreline was first discovered on aerial photographs of the "Big Bend" coast of Florida. The photos which were being studied at that time included one index sheet (Taylor County, Symbol DRE, flown 1959, Sheet 5) and several contact prints (DRE-2W-123, 124; DRE-4W-122, 123; DRE-2W-33; and DRE-2W-29). Stereoscopic coverage is not particularly useful, inasmuch as relief in the area is typically less than one meter per kilometer. Subsequent visits, by boat, confirmed the presence of the submerged feature, locally developed as a completely sub-aqueous sand bar or "beach".

A continuing effort was made, over a period of more than a year, to find suitable materials for dating, so that the age of the minus-two-meter shoreline could be determined. Despite the recovering of several good peats, in various bore-holes, none were geologically located so that they could be used to date the submerged sand bar. The best C-14 information now available is that all peats studied which stand (at present) not more than 50 cm below mean low tide, are 7,800 years old or younger, and represent grasslands or woodlands, rather than marine conditions. The only marine evidences recovered from peats were obtained at distances of one meter or more below present mean low tide. On the basis of this rather tenuous information, and the framework of sea-level rise which is now generally known (cf. Fairbridge, 1961), the minus-one-meter beach is thought to have formed at some time in the most recent 5,000 years.

"ZERO" ENERGY COAST

The "zero" energy coast extends from a point near St. Marks, Florida, to near Tarpon Springs, Florida. The aspect of the coast, through most of this reach, is one of tidal marsh (i.e., saline grasslands), flanked on the landward side by a palm-and-pine forest or a freshwater swamp. Most of the coast is highly irregular, inasmuch as the general wave energy level is too low for any appreciable straightening to have been accomplished. The passage of hurricanes, although momentarily spectacular, is rare enough that the total work done is not altered greatly (Tanner, 1961).

Quartz sand has accumulated at a few places, in the breaker zone, on spits, where local wave refraction produces breakers which average, perhaps, 3 or 4 cm in height. Along much of the coast there are no breakers, no beach, and not even any clearly defined coastline.

The minus-two-meter submerged beach lies, typically, one or two km. offshore. At that point, the water depth (at mean low tide) drops abruptly from about one meter to three meters. A similar scarp also occurs one to two km landward of the present water's edge. In other words, there are two marine scarps in the area, about four km apart; the edge of the Gulf lies about half-way between them. The ground surface slope between these two scarps is less than one meter per kilometer, and may be as little as 20 cm per kilometer. The inner (higher) scarp is capped locally with what appears to be dune sand; the outer (lower submerged) scarp is basically an old beach.

The strip of sea floor between the minus-two-meter beach, and the modern water's edge, is covered with local patches of marsh grass, marine vegetation, clean quartz sand, dark quartz sand rich in organic debris, oyster shells, oyster bars, and rock fragments. The latter are typically chert or limestone; they have weathered out of the Oligocene bedrock which crops out at shallow depths throughout the area.

Sand samples from the drowned beach were composed entirely of clear to limonite-stained quartz, sub-angular and slightly frosted. The median diameter was 1.97 ϕ (0.256 mm). These sands are coarser than those on beaches farther west. The sorting was excellent (So = 1.138; = 0.39), but nevertheless the samples fitted in the general category of zig-zag curves, with apparently two or possibly three modes (Tanner, 1964). A concave break at 1.0 ϕ indicates low-energy surf action (at 3.0 ϕ in the heavy minerals); a convex break at 3.2 ϕ indicates low energy (Figure 2).

Channels crossing the bar are continuations of tidal or ordinary streams, up-channel. Maximum observed channel depths were close to three meters; on the flats adjacent to the channels, water depths were about one meter. These channels show up clearly on the aerial photos listed in a prior paragraph. Each channel has a tight meander pattern, in the fashion of tidal marsh channels; the loop radii, however, are larger than those on tidal flat streams nearby. There is a question, of course, as to how much fill may have accumulated in the channels as sea level rose; until coring has been undertaken, this question cannot be answered. On the basis of present geometry, it is inferred that sea level has risen about 1.6 or 1.7 meters since the bar was exposed as a beach.

DEEPER FEATURES

A Raytheon DE-701 recording fathometer was used to make about 4,000 km of traverse in the area. Most lines were run at right angles to the shore, from about one km to about 15 km offshore. Each traverse was separated, at slope breaks, into more-or-less uniform segments. Most segments seaward of the minus-two-meter "beach" had slopes of about five meters, or less, per kilometer. A number of segments showed landward slope. Statistical analysis of depth data obtained from the profile segments indicates probably lower sea levels at minus 12 m, minus 10 m, and minus 8 m, in addition to the minus-two-meter "beach." A possibly significant inflection was noted locally close to minus six or seven meters.

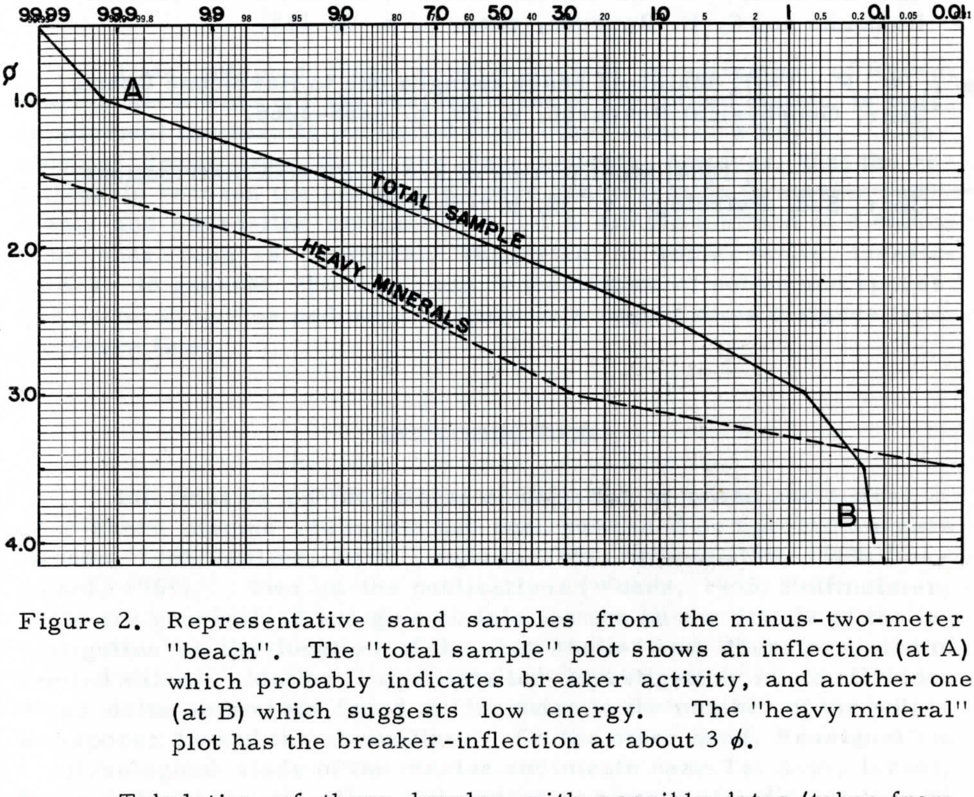

Figure 2. Representative sand samples from the minus-two-meter "beach". The "total sample" plot shows an inflection (at A) which probably indicates breaker activity, and another one (at B) which suggests low energy. The "heavy mineral" plot has the breaker-inflection at about 3 ø.

Tabulation of these levels, with possible dates (taken from Fairbridge) follows:

-2 m	6,000 B.P. or younger
-7	6,000-7,000 B.P.
-8	7,000 B.P.
-10	7,200 B.P.
-12	7,500 B.P.

Evidence continues to accumulate that even Florida is not completely stable. Fault displacements of one to 10 meters, apparently during the period given above, are now known on the peninsula. Therefore the figures for old submerged shorelines cannot be taken as firmly fixed.

Work along the "zero" energy coast is continuing, and will be described in greater detail at a later date.

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ABUNDANCE OF POLLEN AND SPORES IN MARINE SEDIMENTS OFF THE EASTERN COAST OF THE UNITED STATES

by

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ABSTRACT

Data obtained from a palynological investigation of Recent marine sediments off the eastern coast of the United States, in part, supplement the results published from other similar studies. Conclusions drawn from these new data indicate, however, that the relationship between the pollen and spore concentration in marine sediments and shore-line proximity is not a simple function of distance from shore-line as previously suggested by some earlier investigators. In general, the maximum concentration of pollen and spores per gram of marine sediment is found in a region some distance from the shore line.

INTRODUCTION

Information on the lateral distribution of pollen and spores in near-shore marine sediments has been published by several workers (Woods, 1955; Muller, 1959; Leopold, 1959; Hoffmeister, 1960; Rossignol, 1961). Two of the publications (Woods, 1955; Hoffmeister, 1960) are generalized and give no information on the details of the investigation or the location of the area studied and, therefore, are of limited value. Muller, in a detailed investigation of the Orinoco River delta sediments found an increase in the number of the pollen and spores toward the shore-line. On the other hand, Rossignol in a palynological study of the marine sediments near Tel Aviv, Israel, found a decrease of pollen and spores per gram of sediment toward the shore-line from an off-shore position. Similar results were also obtained by Leopold. The abundance of pollen and spores reported by these workers in sediments from the near-shore marine environment ranged from 0 grains per gram (Rossignol) to over 20,000 grains per gram (Woods) of sediment.

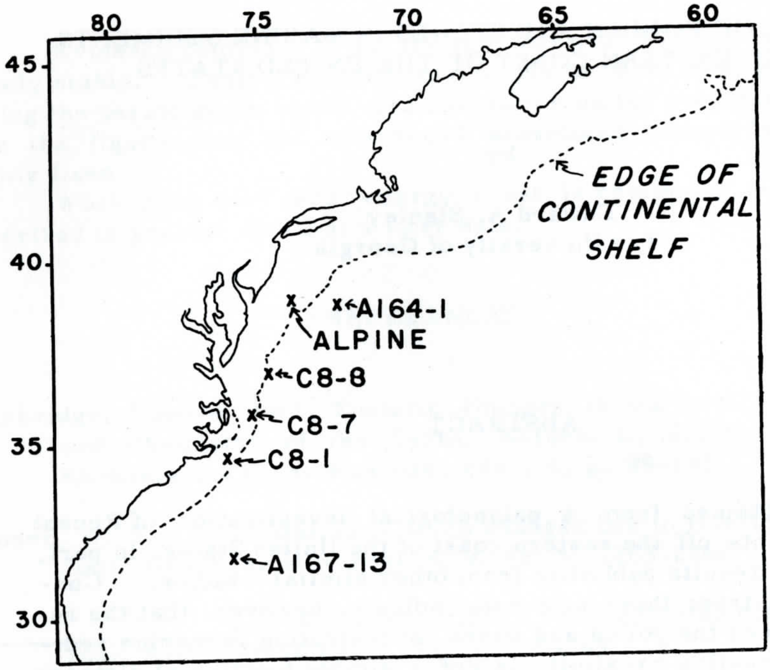

Figure 1. Location of cores sampled off the eastern coast of the United States.

A palynological study of over 200 samples from 13 off-shore and near-shore cores from the continental shelf and slope off the eastern coast of the United States was completed recently by this writer. Of the 13 cores sampled only six of the off-shore cores taken contained abundant pollen and spores of post-Pleistocene age (Fig. 1). In order to meaningfully compare pollen and spore data in marine sediments with other published studies, samples should be of approximately the same age. Therefore, the post-Pleistocene portion of these six cores is thought to be most suitable for a study of the distribution of pollen and spores in marine sediments and also for a comparison of the obtained off-shore palynological data with published near-shore palynological data.

Acknowledgments

This work was supported by a National Science Foundation grant. The writer is indebted to Mrs. M. Maisano for the preparation of a portion of the samples.

Table 1

DETAILS OF CORES DISCUSSED

Core	Latitude	Longitude	Depth of Water (M.)	Distance from Shore (Naut. mil)	Number of Samples	Grains/Gram	
Alpine 9a	39°00'N	73°41'W	46	50	6	102	38
A164-1	38°44'N	71°23'W	2779	180	11	2895	905
A167-13	31°39'N	75°21'W	2880	185	6	1118	674
C8-1	34°38'N	75°39'W	165	20	10	56	30
C8-7	35°56'N	74°41'W	1480	40	4	3013	264
C8-8	37°01'N	74°27'W	1410	80	4	215	182
V12-53	40°54'S	20°22'W	3720	1850	11	--	--
180-74	00°03'S	24°10'W	3330	600	3	--	--

METHODS

When this study was initiated there were no cores available that had been collected in a single traverse perpendicular to the coast-line. Therefore, samples were collected from the available cores (Fig. 1) and the obtained data plotted as distance from shore-line as if they were collected from a single traverse collected perpendicular to the shore-line. There is abundant vegetation on the coast adjacent to the study area and inasmuch as this paper deals not with pollen types (taxa) but only with abundances of pollen it is believed that this manipulation of the core collection positions is justified.

The original position and other pertinent data such as depth of water and distance from shore-line of each core discussed in this paper are listed in Table 1. The cores are stored at the Lamont Geological Observatory. Prior to maceration, each sample was scraped to remove Recent pollen and spore contamination obtained during the storage and sampling of the cores. Usually, between 20 and 22 grams of dry sample were macerated by standard palynological techniques. This involved removal of mineral matter by either or both hydrofluoric and hydrochloric acid treatment. This step was followed by the oxidation of the organic matter, if present. Attempts were made to keep the maceration methods as uniform as possible. However, some variation was necessary, particularly in length of time of treatment, because of differences in sediment composition. The resulting concentration of spores and pollen was diluted to 5 ml. A measured amount (0.15 ml.) of this dilution was placed on a slide and mixed with the mounting medium. The number of pollen and spores on each slide was then determined. From this number was computed the concentration of pollen and spores in each gram of sediment.

In order to reduce possible errors in obtaining the pollen and spore concentration in marine sediments, the absolute number of grains in one sample was averaged with the number of grains in other samples within the same core also of post-Pleistocene age. (The post-Pleistocene age of each sample was determined on the basis of Carbon-14 dates, cold-warm water Foraminifera ratios or pollen and spore data). Errors in both over and under estimation of the number of pollen and spores per gram of sediment, thereby, would tend to balance out.

RESULTS

The average total number of pollen and spores in post-Pleistocene marine sediments in relation to distance from shore-line is shown in Figure 2. A direct relationship also can be shown of abundance of pollen and spores to depth of water. However, the important factor here is the shore-line inasmuch as the pollen and spores are land derived and, therefore, the relationship between

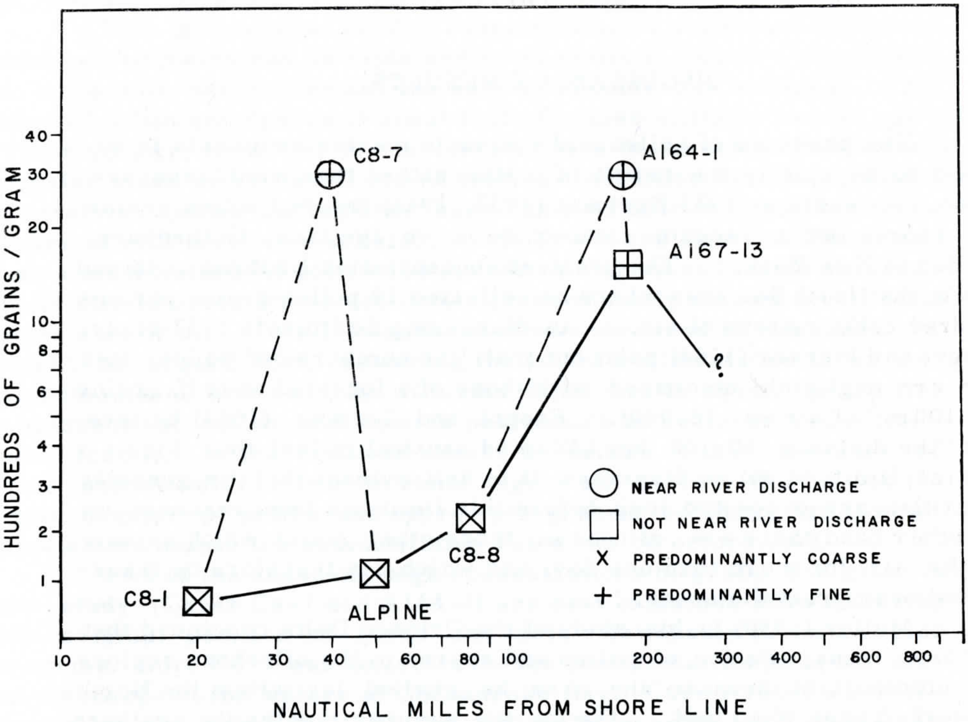

Figure 2. Abundance of pollen and spores in marine sediments in relation to distance from shore-line.

grains per gram and depth of water is not shown. The data presented in Figure 2 are based on analyses and measurements of 41 samples from 6 cores examined from this region of the o cean. Except for some localities with unusually high values (Cores C8-7, A167-13 and A164-1), the number of pollen and spores per gram of off-shore marine sediment slightly increases rather than decreases seaward. The maximum concentration of pollen and spores in this study of the sediments off the eastern coast of the United States is reached at about 185 miles from the present shore-line. Although no samples farther from shore were studied in this area, examination of samples from cores collected approximately 600 miles (Core 180-74; taken near the base of the continental rise off Sierra Leone) and 1850 miles (Core V12-53; in the ocean basin west of the Mid-Atlantic Submarine Ridge) from the closest continent in other areas were essentially barren of pollen and spores. Therefore, it appears that the concentration of pollen and spores per gram of marine sediment does not continue to increase indefinitely seaward but probably reaches its maximum concentration some distance from the shore-line and then decreases farther seaward.

DISCUSSION OF RESULTS

The presence of pollen and spores in marine sediments is believed to be chiefly the result of water rather than wind transportation. As early as 1937 Erdtman (1937, 1942) trapped pollen grains and spóres by a vacuum cleaner on a voyage from Gothenburg, Sweden to New York. The greatest concentration Erdtman obtained was in the North Sea area where he collected 18 pollen grains per one hundred cubic meters of air. In discussing Erdtman's 1937 study, Faegri and Iversen (1964) point out that "the numbers [of pollen] met with are negligible compared with those of a forested area (6 grains per 100 m^3 of air vs. 18,000)." Faegri and Iversen (1964) believe that "the distance 50-100 km [27 to 54 nautical miles] thus forms a natural limit of pollen dispersal. It is self-evident that the greatest quantities are deposited long before this limit has been reached; on the other hand there are, of course, those other grains which remain in the air for more than one day, and which can therefore be transported over great distances."

Muller (1959) in his study of the Orinoco Delta concluded that airborne transportation of pollen and spores to the off-shore regions was unimportant because the area he studied lay within the North Easterly Trade Wind belt. During the summer months the southern portion of the east coast of the United States (up to about 30° North latitude) also lies within the North Easterly Trade Wind belt (Shaw, 1942; Wenstrom, 1942). Whereas the region north of about 30° North latitude comes under the influence of the prevailing South Westerly winds. In this latter region the winds more or less tend to parallel the north-east southwest trending coastline of the United States. In the winter, however, the dominant wind direction for the eastern coastline of the United States is westerly. The detailed influence of the winds on the distribution and concentration of pollen spores in marine sediments is not known. However, it should be noted that during the summer months when there is high pollen and spore production the winds generally tend to come from the ocean or more or less tend to parallel the coast-line. On the other hand, during the winter when pollen and spore production is low the wind direction is from the west. It is fully realized that the wind patterns for the eastern coast of the United States discussed above are greatly over simplified and that one cannot completely disregard the possibility of air transport of pollen and spores to marine sediments. However, because of the generalized prevailing wind directions and because all the data obtained in this study can most easily be accounted for by water transportation it is believed that the wind transportation of pollen and spores to the marine sediments under investigation plays a minor or at best a secondary role compared to that water transportation.

The differences in the concentration of pollen and spores in marine sediments can be explained most easily if they are considered to be part of, and behave as, the normal allochtonous sediment. The size of pollen and spores is about that of coarse silt (1/16 to 1/32 mm). Their density, however, is considerably less inasmuch as they usually consist of an empty shell or, at best, a shell filled with protoplasm. Therefore, pollen and spores have the hydraulic-equivalent of particles of still smaller size (i. e., medium silt and finer). The greatest concentration of pollen and spores in marine sediments theoretically should occur where sediments predominantly of medium-silt and finer size occur. This is exactly what was observed in this study. It might be argued that, assuming the pollen sedimentation in the environments of both sand and silt-clay deposition is equal, the greater abundance of pollen and spores per volume of sediment in the finer size fraction is the result of slower deposition of the finer clastics. This undoubtedly is true to some degree and perhaps this is why the total number of pollen and spores per gram of sediment has limited application unless the sedimentation rates can be determined.

Two of the unusually high concentrations of grains per gram in the study (Cores C8-7 and A164-1) are best explained at this time by the original position of cores and their relationship to major river systems. Core C8-7 was collected on the continental slope in the area of discharge of the waters of Chesapeake Bay. Core A164-1 was collected in the north wall of the Hudson Submarine Canyon; also an area of discharge of a major river system. Both of these contain a dominance of clay-silt size particles and a greater concentration of pollen and spores per unit weight of sediment. Inasmuch as both of the cores are from a region of river discharge it is likely that the abundance of pollen and spores in the core sediments is a direct result of the river bringing into this area of the ocean additional plant microfossils. These spores and pollen grains are then added to the other grains contributed to the sediment by the normal pollen sedimentation in the region. The result is an enrichment of the plant microfossils in the area represented by these two cores.

Core A167-13 which also had an unusually high number of pollen and spores per gram of sediment (1118 grains/gram) was collected from a location on the lower continental rise northeast of the Blake Submarine Plateau (Ericson et al, 1961). The sediments of this core that were sampled for this study were chiefly silt-clay size particles. The collection position of Core A167-13 is not in line with any river discharge paths. Therefore, the high values obtained from this core are tentatively interpreted as being true values for a position approximately 185 nautical miles from the shore-line. Student's t-test performed on Core A164-1 and Core C8-7 (discussed in the preceding paragraph) show no significant difference between these two means whereas the same test performed on data from Cores A164-1 and A167-13 show a highly significant difference between these two means.

Core C8-8, which was also collected on the continental slope slightly north of Core C8-7 in the region between the main discharge paths of Chesapeake and Delaware Bays, contains sediment that is predominantly in the sand-size range. The abundance of pollen and spores per gram of sediment (215 grains/gram) of this core is considerably lower than that in Core C8-7. On the other hand, Core Alpine 9a, which contains both silt-clay and sand sized particles, and Core C8-1 which is composed of a foraminiferal sand, both contain a lower concentration of pollen and spores per gram (102 grains/gram and 56 grains/gram, respectively) than Core C8-8.

SUMMARY

The abundance of pollen and spores per gram in the marine sediments investigated in this study increases seaward from a position of about 20 miles from the shore-line. The maximum concentration is reached at a distance of about 185 miles from the present shore-line. Seaward from this position, the abundance of pollen and spores probably decreases. The two exceptions to this trend are in cores collected in the regions where rivers empty into the ocean. In these regions the number of pollen and spores per gram of sediment is considerably larger than in other areas investigated. The greater abundance of grains per unit of sediment is thought to be the result of the pollen and spores contributed to the sediment being supplemented by additional pollen and spores brought in and added to the sediment by the river systems.

This interpretation in no way precludes an increase in the concentration of pollen and spores per unit volume of sediment in the vicinity of the shore-line as suggested by former investigators (Woods, 1955; Muller, 1959; Hoffmeister, 1960). This is especially true if one includes lagoons and marshes in the study. However, some of the conclusions presented by these workers may be re-interpreted as not being an increase in the number of grains per gram toward a shore-line but an increase in the number of grains per gram toward a river mouth or delta. (This observation was also briefly mentioned by Muller.) The distribution of the pollen and spore concentration in Recent sediments has many interesting paleoecological applications. Therefore, this preliminary endeavor should be supplemented by more detailed investigations when a moderate number of systematically collected continental-shelf and slope cores becomes available.

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FAULTED ALLUVIAL AND COLLUVIAL DEPOSITS ALONG THE BLUE RIDGE FRONT NEAR SALUDA, NORTH CAROLINA

by

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and
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North Carolina Department of Conservation and Development
Division of Mineral Resources

ABSTRACT

Alluvial and colluvial deposits of Pleistocene or Pliocene age are described near Saluda, North Carolina. These deposits occur in the Southern Blue Ridge region and rest upon rocks which are assigned to the Inner Piedmont suite. The fact that these sediments and underlying bedrock are displaced by faults indicates tectonic activity late in this region's geologic history.

INTRODUCTION

Reconnaissance mapping along the Blue Ridge front near Saluda, Polk County, North Carolina, in the fall of 1962 revealed two deposits of unconsolidated sediments displaced by faults. Other rare instances of faulted unconsolidated deposits have been reported in Washington, D. C. (Carr, 1950), in Virginia (White, 1952, and Nelson, 1962), and in North Carolina (White, 1952). The two deposits reported in this paper and the two reported by White brings to four the number of such deposits known to occur in North Carolina.

GEOLOGIC SETTING

Both of these deposits lie on a well dissected plateau just west of the Blue Ridge front and occur at about the 2000 foot elevation. The rocks of this area are assigned to the Inner Piedmont suite of King (1955, p. 353). This suite consists of sillimanite schists, quartzites, and hornblende gneisses and schists that, except for small unassimilated islands, has been metasomatized at catazonal depths into layered gneisses, migmatites, and granites (Conley and Drummond, 1964). The major rock type of the Saluda area is migmatite, which is probably the outer zone of a granite body that, a few miles to the southwest, reaches batholithic proportions.

The Saluda area contains a number of white to gray-white alluvial terraces. These terraces have been noted throughout the Southern Piedmont and Mountain regions of North Carolina. They are the remnants of old valley fill that is probably of Pleistocene or even Pliocene age. The antiquity of these deposits is shown by their stratigraphic position and the fact that weathered, rounded K-feldspar fragments, ferruginous concretions, and iron cemented sands are oftentimes found in them. Usually the deposits contain a basal gravel of well rounded, bleached quartz pebbles and cobbles in a clayey-sand matrix. The basal gravel grades upward into interbedded, moderately well sorted, grayish-white plastic clay and white quartz sand. In some localities the clay beds contain carbonaceous material and carbonized wood.

A dark brownish-red deposit of colluvial material at a number of localities is draped over sloping bedrock surfaces as well as, in some exposures, the alluvial terraces. Such colluvial deposits are numerous in the Upper Piedmont and Blue Ridge regions of Polk

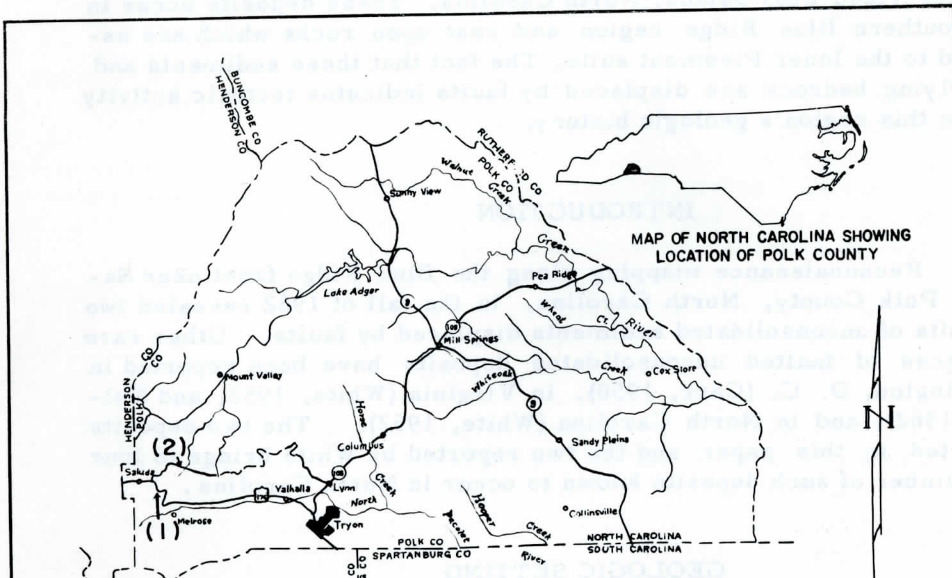

Figure 1. Map of Polk County, North Carolina, showing location of faulted alluvial and colluvial deposits.

County, North Carolina. They are composed of unsorted, dark brownish-red silt and clay with some sand and occasional random angular to subrounded pebble and cobble sized fragments of quartz, granite, and gneiss. The basal part of the colluvial deposits is sometimes a curdely bedded, poorly sorted red sand.

DESCRIPTION OF THE FAULTS

A fault that has displaced unconsolidated colluvium and underlying bedrock is located on the west side of U. S. Highway 176, 1.5 miles south of Saluda. Here normal fault movement has downdropped a 16 foot thick bed of yellowish-red colluvium, underlain by weathered migmatite, against relatively unweathered migmatite. The fault plane separating these diverse rock types strikes N8°E and dips 67°SE. Striations, slickensides, and fault gouge, up to one-quarter inch thick, are well developed in the fault plane and represent the visible deformation produced by fault movement. The striations are oriented S87°E and plunge in the plane of the fault. Manganese and halloysite, which usually occur in other slickensided faults in this area, are conspicuously absent.

At least 16 feet of dip-slip movement can be measured at this locality. Other lines of evidence, such as the extremely weathered condition of the migmatite underlying the colluvium of the hanging wall and the barely weathered condition of the migmatite of the footwall, indicate that this figure is conservative.

The other deposit of unconsolidated sediments, offset by faults, occurs on the northwest side of the Howard Gap Road, 1.6 miles due east of Saluda, and 240 yards northwest of a bridge over Cove Creek. At this locality three displacements have been noted (Fig. 2). They are:

(1) A thrust fault that strikes about N80°E and dips 11°SE. Striations developed on the fault plane plunge S10°E at 11°.

(2) A right lateral strike-slip fault that strikes N20°E. The fault plane is a curved surface that dips 30° to 70° SE, and is truncated by the thrust fault. Striations developed on this fault surface consistently strike S20°E and are horizontal.

(3) A small tear fault that strikes N6°W and dips 15°NE. Slickensides developed on this fault surface plunge S15°E at 4°.

The first movement must have been along the thrust fault.

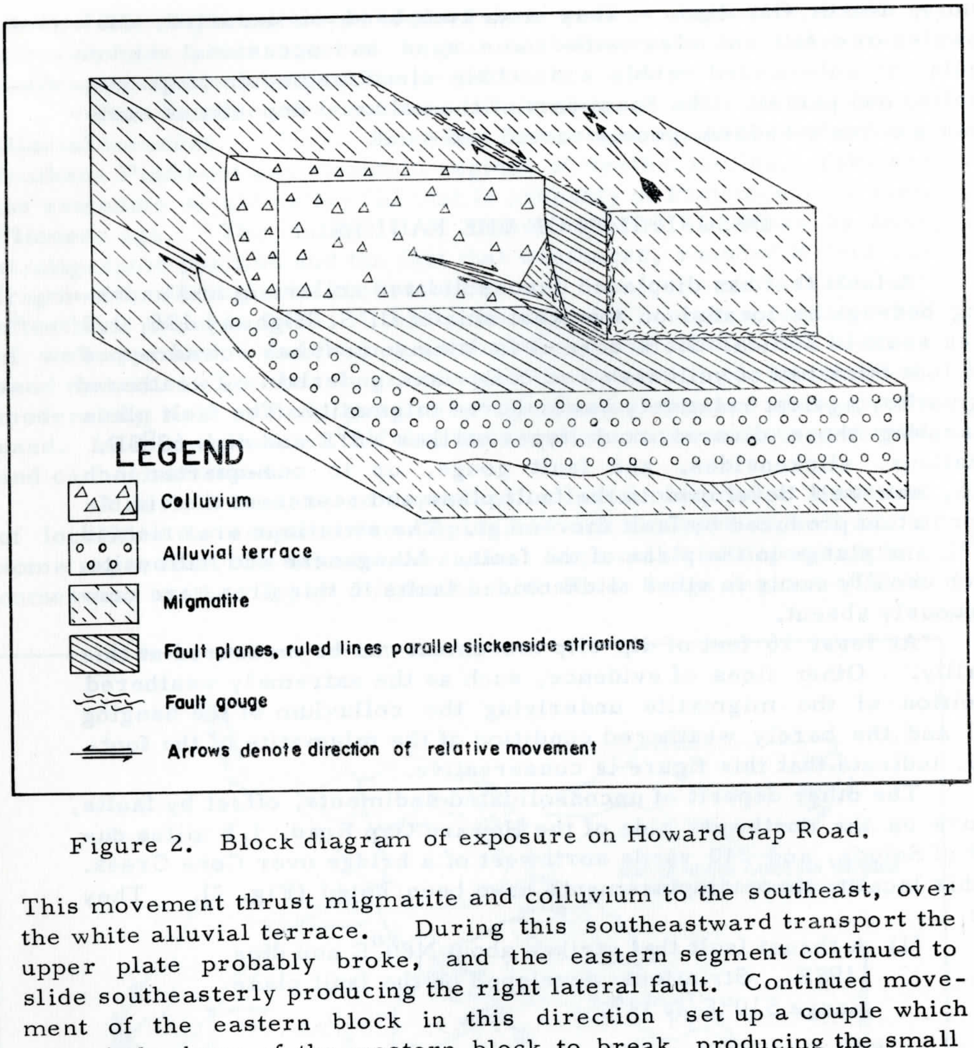

Figure 2. Block diagram of exposure on Howard Gap Road.

This movement thrust migmatite and colluvium to the southeast, over the white alluvial terrace. During this southeastward transport the upper plate probably broke, and the eastern segment continued to slide southeasterly producing the right lateral fault. Continued movement of the eastern block in this direction set up a couple which caused the base of the western block to break, producing the small tear fault. Absolute amounts of movement in these faults is not discernable, but the minimum amount allowable has to be on the order of several feet.

Slickensides are well developed in all of the fault planes. Striations occur in profusion on the slickensided surfaces. Movement along the various faults was accompanied by much grinding of the migmatite which produced up to 8 inches of gouge. Upon weathering this gouge becomes a greasy feeling, brown vermiculitic clay.

To check the possibility that these faulted deposits could have developed by slumping, obvious slump and landslide features in the area were carefully examined. Neither slickensides and striations nor gouge were found, either between individual parts of such zones or between the slumping material and bedrock. The slickensides and gouge are, therefore, considered to be products of faulting.

CONCLUSION

The presence of faults that displace alluvial and colluvial deposits that are of probable Pleistocene age indicates tectonic activity along the Blue Ridge front at a very late date in this region's geologic history.

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